(12) UK Patent Application (19) GB (11) 2 322 236 (13) A

(43) Date of A Publication 19.08.1998

(21) Application No 9803043.0

(22) Date of Filing 12.02.1998

(30) Priority Data
(31) 9701753 (32) 14.02.1997 (33) FR

(71) Applicant(s)
Dassault Electronique
(Incorporated in France)
55 quai Marcel Dassault, F-92210 - Saint Cloud, France

(72) Inventor(s)
Guy Courtet
Christian Renard

(74) Agent and/or Address for Service
J. A. Kemp & Co.
14 South Square, Gray's Inn, LONDON, WC1R 5LX, United Kingdom

(51) INT CL^6
H01Q 1/36

(52) UK CL (Edition P)
H1Q QDJ
U1S S2212 S2215

(56) Documents Cited
EP 0320404 A **WO 92/05602 A** **US 5541617 A**

(58) Field of Search
UK CL (Edition P) **H1Q QDA QDJ**
INT CL^6 **H01Q 1/36 11/08**
On-line: WPI

(54) Abstract Title
Ultrahigh frequency antenna element

(57) A UHF antenna element comprises a radiating member including a plurality of radiating strands, a feeder and a connector (3 Figure 2) between the feeder and the member, the strands and at least a portion of the connector being made by engraving a dielectric substrate e.g. a flat PCB 2, an external screen (5 Figure 5) being provided over the engraved portion of the connector. In an embodiment, the element comprises a plastics cylinder (1) supporting a bifilar or quadrifilar helical radiating member (21-24 Figure 2). Alternatively the element comprises an engraved metallised cylinder. The external screen (5) is a metallised sleeve of PTFE or GRP partially covered by a cap 6 which is slid down over the sleeve once it has been connected (Figures 6 to 8, 12 and 13). An insert (7 Figures 10 and 11) within the cylinder 1 allows it to be secured and grounded to a plate (85 Figure 13).

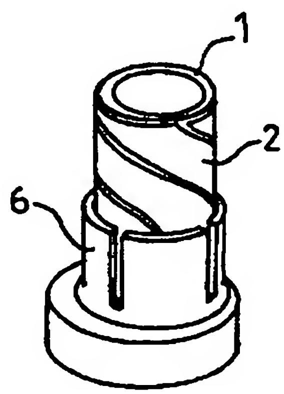

FIG. 8

GB 2 322 236 A

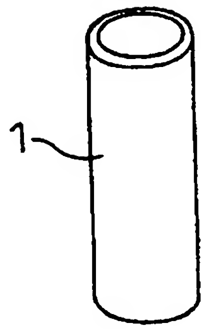

FIG.1

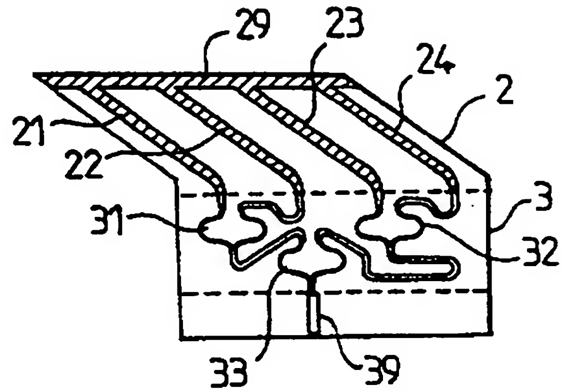

FIG. 2

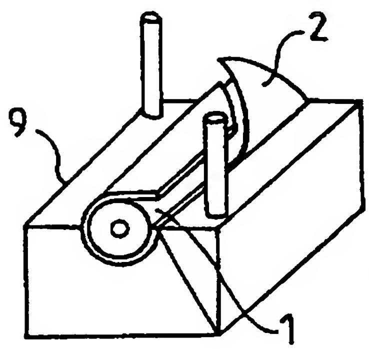

FIG. 3

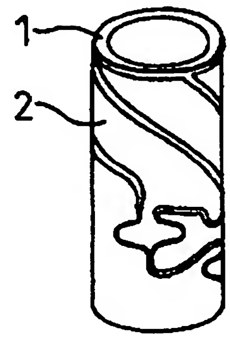

FIG. 4

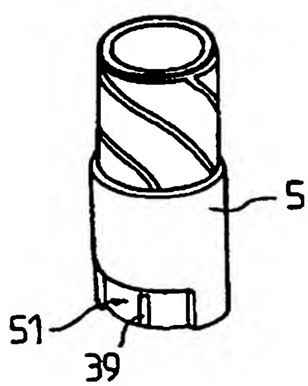

FIG.5

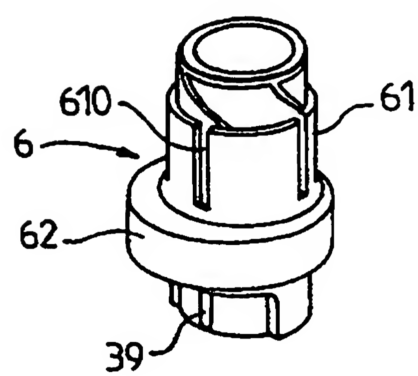

FIG. 6

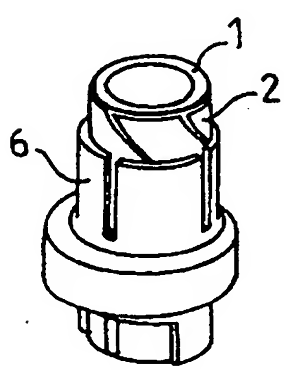

FIG.7

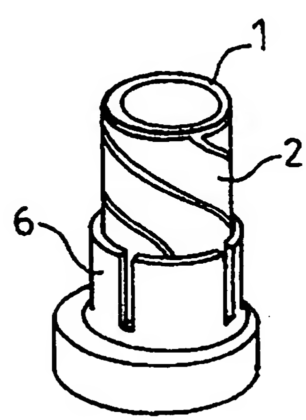

FIG. 8

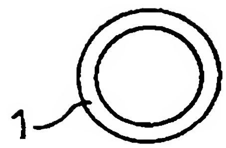

FIG.9A

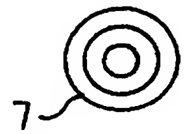

FIG.10A

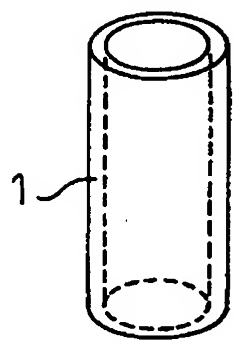

FIG.9

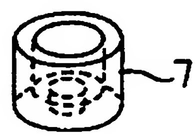

FIG.10

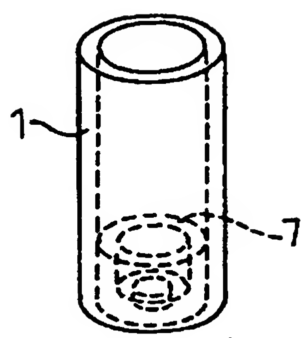

FIG.11

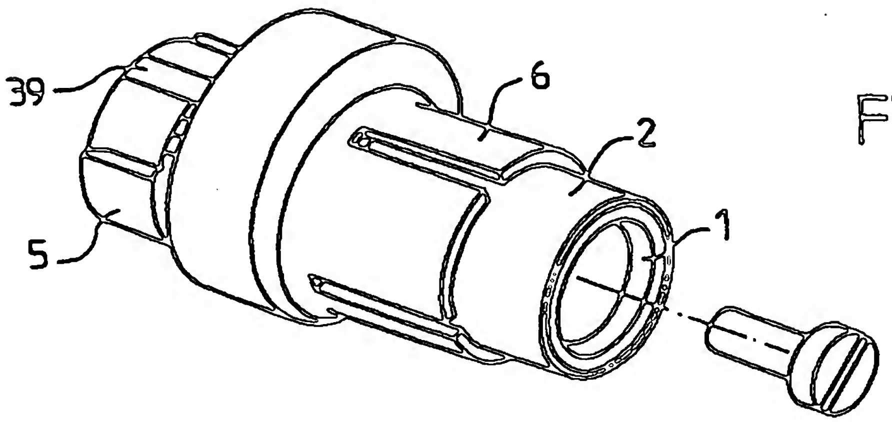

FIG.12

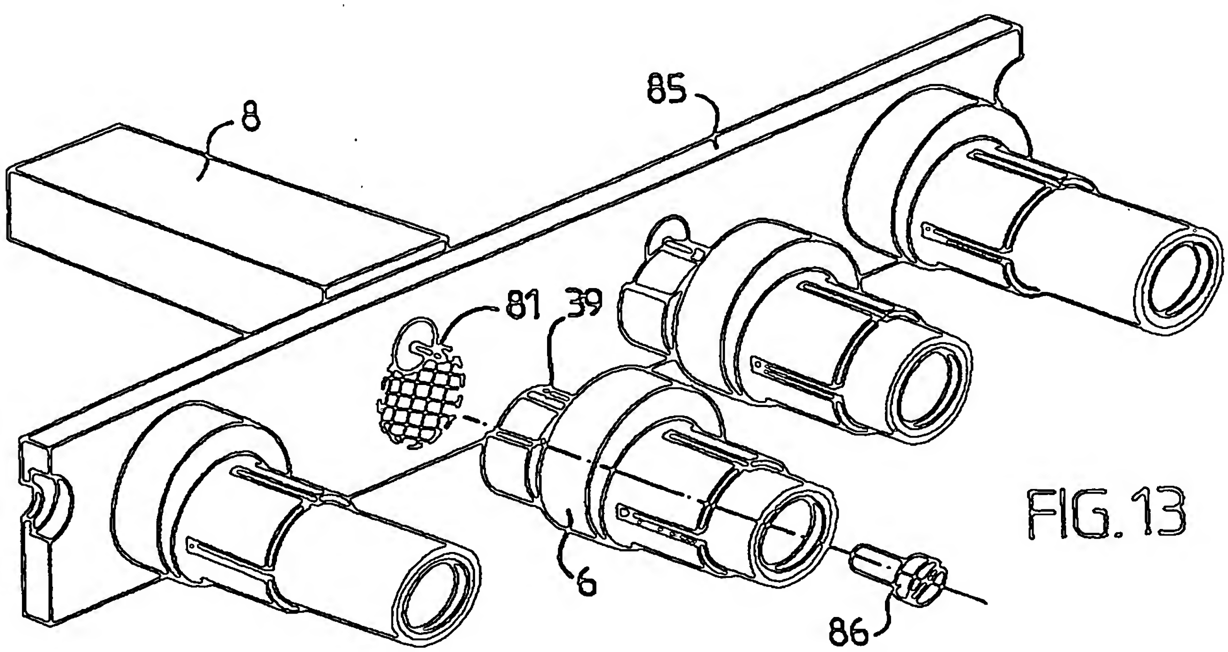

FIG.13

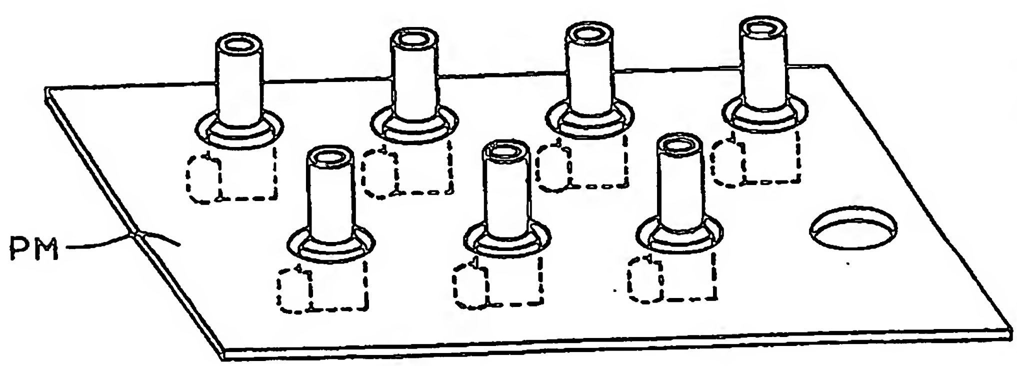

FIG.14

2322236

ULTRAHIGH FREQUENCY ANTENNA ELEMENT

The invention concerns ultrahigh frequency antenna elements that can be used in the form of an array arrangement for various telecommunication applications. For example, antennas of this type operating at over 5 GHz with a maximum electronic target scanning range of approximately 70° permit land telecommunications between various movable objects, as well as telecommunications between satellites and the earth.

These telecommunications are often effected in circular polarization. So-called "helical" antenna elements are particularly suitable for these applications.

These helical antennas which are, for example, a resonant quadrifilar helix with longitudinal radiation, have a radiation pattern in the general form of a cardioid, with a good quality of circular polarization, as well as an extensive angular coverage around the longitudinal axis.

However, it becomes difficult to use helical type radiating elements when ultrahigh frequencies are reached. Indeed, difficulties are then encountered in feeding or "energizing" this type of radiating element in a reliable manner. These difficulties are aggravated in an array antenna, where it is necessary to avoid coupling phenomena between the adjoining radiating elements and their energizing or feeding circuits. The space requirement is also an important factor, since in

electronic scanning applications, a mesh (the pitch between radiating elements) is sought that is closer, the wider the angular pointing zone of the beam. Moreover, it is generally desirable for the radiating characteristics of the antenna to be well defined, in particular their phase centre, which makes it necessary to mount the radiating element in a position adjusted relative to a reflecting ground plane; as this has to be situated virtually at the level of the energizing circuits (connection of a feeder circuit towards the strands of the helix), the great difficulty which exists in correctly establishing such a ground plane will be appreciated.

The object of the present invention is to improve the situation.

The present invention may be applied to an element of an ultrahigh frequency antenna of the type comprising a shaped part, (for example, cylindrical) supporting several radiating strands which together define a radiating element (for example of the type of a bifilar or quadrifilar helix), ultrahigh frequency feeder means (or a source) and ultrahigh frequency connecting means (or a distributor) between the feeder means and the radiating strands.

According to one aspect of the invention, the radiating strands and at least a portion of the ultrahigh frequency connecting means are obtained by engraving on one and the same dielectric substrate, and external screening is provided at the level of the said engraved portion of the ultrahigh frequency connecting means.

In a preferred embodiment, a short-circuit ring is provided at one of the ends of the radiating strands, and the connecting means are connected to the other end of these strands.

The substrate may be a flat printed circuit wound up on the shaped part, or be defined by the shaped part itself whereon the radiating strands and the said portion of the connecting means are obtained by direct engraving.

The external screening advantageously comprises a sleeve conductive at least on its surface, externally surrounding the said portion of the ultrahigh frequency connecting means. Preferably the conductive sleeve comprises a dielectric substrate metallized on its outside, directly surrounding the said portion of the ultrahigh frequency connecting means, and a conductive metallization is provided inside the shaped part, which forms a strip line structure at the level of the said portion of the connecting means. The sleeve is advantageously cut away at the level of the point of connection to the feeder system.

It is advantageous to provide, moreover, a conductive cap of a generally cylindrical shape around the sleeve, which cap may be provided with longitudinal slots allowing it to hold the sleeve tightly on the substrate.

In a particular embodiment, the cap comprises a long cylindrical section tightly holding the sleeve on the substrate, and extended in an axially offset cylindrical ring accommodating a microstrip connection on the side of the feeder means.

For its part, the internal conductive metallization may be defined by an insert positioned in the bottom internal portion of the shaped part. And this insert may be arranged so as to allow the radiating element to be fixed on a support.

The connecting means preferably comprise a distributor, formed in particular by Wilkinson-type dividers.

The device may be mounted for passing through a hole of a ground plane in a chosen region, close to the free emergence of the radiating strands.

The device may have a one-dimensional or two-dimensional arrangement, chosen from similar radiating elements mounted in the same ground plane.

According to another aspect of the present invention, there is provided a method manufacturing an ultrahigh frequency antenna element.

Other characteristics and advantages of the invention will become apparent from the detailed description given below by way of non-limitative example with reference to the accompanying drawings in which:

- Figures 1 to 8 illustrate successive steps of mounting a quadrifilar helical antenna element in accordance with the present invention;

- Figures 9, 10 and 11 illustrate the mounting of an insert inside the shaped part supporting the radiating strands;

- Figure 12 illustrates an almost finished antenna element;

- Figure 13 illustrates several antenna elements forming a one-dimensional array, at different stages of their mounting; and

- Figure 14 illustrates a two-dimensional array formed by antenna elements in accordance with the present invention.

The elements of the attached drawings are, for the most part, of a definitive nature. They can, therefore, not only serve to make the present invention more readily understood, but can also contribute to the definition of the latter, if required.

Figure 1 illustrates a shaped part 1, which is here a cylinder of revolution, made of a dielectric material such as polysulphone, PTFE (polytetrafluoroethylene), or a copolymer of polystyrene such as Stycast (trade mark).

Figure 2 illustrates a flexible printed circuit comprising a substrate 2, whereon there are engraved in an inclined zone four wires or strands 21 to 24 joined to the horizontal free edge by a short-circuit means 29. The straight (not inclined) portion takes up the strands in pairs at a first level of Wilkinson dividers 31 and 32, while their common points are joined by lines of an appropriate length to a second dividing level, here com-

prising a Wilkinson divider 33 whose common point defines a feeder line 39 in the bottom portion of Figure 2.

As shown in Figure 3, this flexible printed circuit can be wound up on the cylinder 1 (metallization towards the outside), to which it is fixed by bonding. The inclined zone is closed up, as may be seen at the rear of Figure 3. All this can be done in a tool schematically outlined under the reference numeral 9, and comprising a groove of a shape appropriate to the external shape of the unit. The vertical pegs serve for the positioning of a counterpart, for example for the bonding.

After the bonding, the short line 29 has become a ring whose two ends are welded or soldered to ensure the electrical continuity.

The rest of the connection between the edges of the printed circuit 2 is situated at points without any metallization.

Figure 4 shows the result obtained, where three helical strands will be discerned, as well as the portion of the Wilkinson divider system.

A sleeve 5 is placed round this (Figure 5), which is formed by a dielectric sheet that is metallized on its outside. The dielectrics of the sheet, as well as of the flexible printed circuit 2 are, for example, substrates used for making printed antennas that are sufficiently flexible for permitting the winding up, for example, of the pure PTFE (polytetrafluoroethylene) type, or

reinforced with glass microfibres.

In the sleeve 5, a cutout 51 is provided in the bottom portion, which shows the line 39 intended to be connected to the ultrahigh frequency feeder circuit.

Subsequently, a cap 6 is used which is here formed by two cylindrical portions in each other's extension. The upper cylindrical portion 61 is internally formed so as to follow the outside of the unit formed by the cylinder 1 and the printed circuit 2. Preferably, this cylindrical portion 61 is provided with slots, such as 610, which allow it to grip the elements situated inside it in a better way. At the bottom, the cap has a cylindrical ring 62, axially offset towards the left so as to provide more space in its hollow portion (at the bottom, not visible) opposite the cutout 51 which shows the input line.

At this stage of assembly, the cap 6 is left in the intermediate portion on the radiating element, as indicated in Figure 6.

The position is thus that of Figure 7. After a welding or soldering operation to which we will revert below, the cap 6 is caused to be lowered down to the bottom by becoming flush, or almost flush, with the bottom portion of the cylinder 1.

We will now examine the contents inside this cylinder 1. Figures 9 and 9A show a side view and a top view (in a machine drawing in the French manner) of this cylinder 1. Figures 10 and 10A show two corresponding views of an insert 7 that will be

placed inside this cylinder 1 in its bottom portion. This insert 7 is a hollow cylindrical ring closed at one of its ends, except for the passage of a hole intended for a screw. Figure 11 illustrates the insert 7 installed inside the sleeve 1.

This installation of the insert in the sleeve may be effected before the operation described with reference to Figures 1 to 8.

Figure 12 shows how a screw can be passed inside the cylinder 1 to allow the unit to be fixed on a support (the plate 85 of Figure 13).

At the rear portion of Figure 13, a ultrahigh frequency feeder circuit with a phase shifter has been schematically illustrated at 8. The skilled person will know how to make such circuits requiring little lateral space. Such a circuit (or the corresponding function in a circuit of larger size) does, of course, exist for each of the antenna elements illustrated. A feeder output is defined by a pin 81. Thus the radiating element is at first secured to the plate 85 by means of screw 86, so that its long feeder plug is just at the level of the pin 81. These two elements are welded or soldered to one another. It is only after this, that the cap 6 is lowered to come flush with the supporting plate 85, as may be seen in two other radiating elements of Figure 13.

Figure 14 shows that a two-dimensional array of radiating elements, mounted in a chosen position relative to a ground plane PM, can be disposed in this way, the latter being fixed, for

example, relative to the plate 85. It will be observed that the ground plane is situated practically at the level of the point where the helical radiating strands project from the caps 6.

The invention lends itself to diverse variants.

First of all, there may be variants in the structure of the helix itself. The feeding is effected via the bottom for a helix with four strands, whose real strand lengths are equal to an integral number of half-wavelengths. They may be left in an open circuit if the strand lengths are equal to an odd number of the quarter wavelengths.

In all these cases, each one of the strands is energized with an identical amplitude and a phase law rotating over 360°, taking into account the distribution of the strands round the cylindrical support. The direction of the winding of the strands and the direction of the rotating phase determine the direction of the radiation and the direction of the circular polarization.

The detailed description given herein refers to a helical antenna on a cylindrical shaped part. The invention could, of course, also be applied to the "degenerate" antenna obtained with straight strands along a generator of the cylinder. It could also be applied to any antenna structure mounted on a shaped part and having a general structure similar to that described; it is, in particular, possible to apply it generally in the case of any cylindrical structure with a base other than circular, it being possible for this base to be a curve or a polygon. It may also

be generally applied to conical surfaces for example.

Technologically, the embodiment described uses a printed, engraved, cut-out circuit, wound and bonded to the hollow plastic cylinder.

It is, of course, also possible to proceed with a direct engraving of the metallizations on the hollow dielectric cylinder (made for example of PTFE or Stycast), in particular for manufacturing antennas in large quantities.

Moreover, the internal part of the "triplate" or "strip line" structure, which is situated at the level of the Wilkinson dividers (more generally of the distributor, or of the "connecting means") has been described above, as defined by a metal insert positioned with precision inside the cylinder. As a variant, or additionally, it is also possible to metallize the inside of the cylinder locally at the level of this "distributor".

By using the metal insert for fixing the antenna element on a conductive support, a good ground contact is also obtained.

The feeder device 8 with phase shifters may be constituted by phase shifters with lines switched by diodes, for example.

In the description given, the screening cap is obtained by closely following the rest of the structure so as to obtain a "triplate" cross-section at the level of the feeder distributor.

A variant would lie in positioning this screening cap at a distance, to give this part a microstrip-technology structure.

Making the cap from two eccentric cylinders is advantageous for reasons of ease of manufacture. However, it is not restrictive. This cap may also be obtained by means of a metallized synthetic material which may have a different shape, for example that of extensions widening opposite the feeder line 39, as sketched in Figure 14 beneath the ground plane PM. It would also be possible to use materials with a shape memory for this purpose.

It is important to observe that the device described can be completely dismantled without the risk of any major damage, in particular at the level of the connection to the ultrahigh frequency feeder circuit 8.

In the Wilkinson dividers, the positioning of optional decoupling resistors may be effected by means of so-called "chip" resistors which are very thin, or better still, resistors printed on a very thin substrate which is then, for example, a Kapton film, or even resistors engraved on the printed circuit; an "omega-ply" type structure is then used, which includes a resistive layer through which the level of the resistors is reached.

The description given refers to Wilkinson dividers which are at present considered to be preferable. However, it is also possible to use distributors formed by couplers in steps, rings or yet again as a single T. In this case, it is possible to implant only a portion of the structure of the distributor on the

printed circuit 2 (or the direct engraving on the cylinder 1). This is sufficient to leave space for an adjusted positioning of the ground plane, while the rest does not require a large space at the rear, and can be positioned transversely.

In the conventional manner, the antenna element may be provided with an impedance of 50 ohms. The adaptation of the impedance between the radiating strands themselves and the dividers is then effected in that the strands are wider, as may be seen in the drawings. The adaptation of the impedance between the strip-line structure and the feeder system is obtained by a slight widening of the conductive zone: in Figure 2 it will be observed that this conductive zone 39 is wider than the zones used inside the core itself of the distributor 3.

To sum up, the radiating element is made as follows:

- Preparing the first part (the cylinder with the metallic engraving of the strands and of the feeder circuit), the engraving being direct on the cylinder or obtained by bonding a flexible printed circuit onto the same cylinder.
- Positioning optional resistors for decoupling the couplers in the distributor circuit.
- Winding up the counterplate (technique of wound-up substrates), positioning this counterplate, the sleeve and then the cap halfway.
- Plating, eg by copper, at the level of the input line 39 of the distributor (for example, for a gilded line, if required).
- Positioning the helical element, for example by screwing it

onto its support.

- Welding or soldering the input line of the distributor to the output line of the ultrahigh frequency feeder system with phase shifting for example.
- Lowering the screening cap into its final position.

The proposed radiating element has various advantages:

- a small space requirement, mechanically compatible with being placed into a "tight" array, in particular thanks to the winding up of the feeder distributor 1 towards 4,
- no stray radiation by the feeder distributor (by using screened printed technologies of the screened strip line and microstrip-type),
- a technology compatible with use at a relatively high ultrahigh frequency output,
- an easy connection to printed circuits, for example the modules of an antenna array with electronic scanning as described, or yet to a coaxial connector,
- scope for assembly/dismantling with protection of the connection (screening) and rigid mounting (screwing being possible),
- an easy positioning of a reflector panel of the perforated metal plate-type, with an adjustable position at the rear of the radiating strands so as to modify the shape of the radiation pattern of the radiating element,
- reduced weight, and
- reproducible manufacture (printed-circuit technology).

One of the characteristics of the invention is in particular the simplicity and efficiency of the method of manufacturing the proposed antenna. However, the invention is not limited to the object the detailed description whereof has been given. Diverse variants are envisaged. More generally, the invention may be applied to making the whole or part of the ultrahigh frequency connecting means between radiating strands or wires and an ultrahigh frequency feeder system (not necessarily with phase shifting), whenever it is necessary to have a very small space requirement available in the vicinity of the free emergence of the radiating wires or strands, for example, for fixing a ground plane at that point.

CLAIMS

1. An ultrahigh frequency antenna element, of the type comprising a shaped part supporting several radiating strands which together define a radiating element, ultrahigh frequency feeder means, and ultrahigh frequency connecting means between the feeder means and the radiating strands,

wherein the radiating strands and at least a portion of the ultrahigh frequency connecting means are obtained by engraving on one and the same dielectric substrate, and external screening is provided at the level of the said engraved portion of the ultrahigh frequency connecting means.

2. An antenna element according to claim 1, wherein the shaped part is cylindrical.

3. An antenna element according to claim 1 or 2, wherein two radiating strands are arranged as a radiating element of the bifilar helix type .

4. An antenna element according to any one of the preceding claims, wherein four radiating strands are arranged as a radiating element of the quadrifilar helix type

5. An antenna element according to one of claim 3 or 4, wherein a short-circuit ring is provided at one of the ends of the radiating strands, and the connecting means are connected to the other end of these strands.

6. An antenna element according to any one of the preceding claims, wherein the substrate is a flat printed circuit wound up on the shaped part.

7. An antenna element according to any one of claims 1 to 5, wherein the substrate is defined by the shaped part itself, whereon the radiating strands and the said portion of the ultrahigh frequency connecting means are obtained by direct engraving.

8. An antenna element according to any one of the preceding claims, wherein the external screening comprises a sleeve conductive at least on its surface, externally surrounding the said portion of the ultrahigh frequency connecting means.

9. An antenna element according to claim 8, wherein the conductive sleeve comprises a dielectric substrate metallized on its outside, directly surrounding the said portion of the ultrahigh frequency connecting means, and a conductive metallization is provided inside the shaped part, which forms a strip line structure at the level of the said portion of the ultrahigh frequency connecting means.

10. An antenna element according to claim 9, further comprising a conductive cap of a generally cylindrical shape around the sleeve.

11. An antenna element according to claim 10, wherein the cap is provided with longitudinal slots allowing it to hold the sleeve

tightly on the substrate.

12. An antenna element according to claim 10 or 11, wherein the cap has a long cylindrical section tightly holding the sleeve on the substrate and extended in an axially offset cylindrical ring accommodating a microstrip connection on the side of the feeder means.

13. An antenna element according to any one of claims 9 to 12, wherein the internal conductive metallization is defined by an insert positioned in the bottom internal portion of the shaped part.

14. An antenna element according to claim 13, wherein the insert is arranged so as to allow the radiating element to be fixed on a support.

15. An antenna element according to one of claims 10 to 14, wherein the sleeve is cut away at the level of the point of connection to the feeder system.

16. An antenna element according to any one of the preceding claims, wherein the connecting means (3) comprise a distributor, formed in particular by Wilkinson-type dividers.

17. An antenna device according to any one of the preceding claims, wherein it is mounted for passing through a hole of a ground plane in a chosen region close to the free emergence of the radiating strands.

18. An antenna element according to claim 17, having a one-dimensional or two-dimensional arrangement chosen from similar radiating elements mounted on the same ground plane.

19. An ultrahigh frequency antenna element constructed substantially as hereinbefore described with reference to the accompanying drawings.

20. An array of antenna elements each constructed according to any one of the preceding claims.

The Patent Office

19

Application No:	GB 9803043.0	Examiner:	J L Freeman
Claims searched:	1 to 20	Date of search:	7 May 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H1Q (QDA, QDJ)

Int Cl (Ed.6): H01Q (1/36, 11/08)

Other: On-line: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0320404 A1	(Centre National D'Etudes Spatiales) Figures 2a to 3d.	1, 2, 4 & 6
X	WO 92/05602 A1	(Garmin International) Figures 5 & 6	1, 2, 4 & 6
X	US 5541617	(P J Connolly *et al*) Figures 1, 4 & 5	1, 2, 4 & 6

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.